A 3D reconstruction from real-time stereoscopic images using GPU

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***Abstract*—In this article we propose a new technique to obtain a three-dimensional (3D) reconstruction from stereoscopic images taken by a stereoscopic system in real-time. To parallelize the 3D reconstruction we propose a method that uses a Graphics Processors Unit (GPU) and a disparity map from block matching algorithm (BM). The results obtained permit us to accelerate the images processing time, measured in frames per second (FPS) with respect to the same method using a Central Processing Unit (CPU). The advantage of speed using GPU advocates our system for practical applications such as aerial reconnaissance, cartography, robotic navigation and obstacle detection.**

Keywords—real-time; Graphics Processing Units (GPU); stereoscopic images; block matching; 3D reconstruction

I. INTRODUCTION

The 3D reconstruction from stereo images is a topic of active research in tasks such as image segmentation for object recognition and the construction of 3D scene models in image-based rendering. Stereovision involves two processes: the binocular of features observed by the two images and the reconstruction of their 3D preimage from matching the same point over the two images. Due to image formation, in order to avoid erroneous reconstruction measurements some methods must be designed to establish the correct correspondence between images features in real-time 3D reconstruction feedback. Examples include machine vision in robotics task where feedback for autonomous control is required in robotics for navigational decision-making [1].

There also been a resurgence of 3D reconstruction in entertainment industry, from computer games to theatrical release, demanding synthetic pictures of real scenes mixed with images of artificial objects, defined like image-based rendering. In these type of applications, speed is more important than precision.

Actually the semiconductor industry, follow the many-core focus for designing microprocessors with a large number of far smaller cores and the number of cores doubles with each generation [2]. These processors vary in their microarchitectures, imposing a challenge: to benefit from the continued increase of computing power. Graphics Processing Units (GPUs) are specialized many-core processors that are optimized for graphic processing, with for instance floating point calculation and matrix operation.

Graphical tasks are highly parallelizable. In contrast to CPU, the GPU works using a different approach, the GPU divides the resources of the processor among the different stages, such that the pipeline is divided in space, not in time [3], [4]. Other characteristic is that processor output on one stage feeds directly into the next stage, exploiting data parallelism within that stage, in order to process multiple elements at the same time. It is some kind of massive hyperthreading.

In 2006 NVIDIA [5], introduced Compute Unified Device Architecture (CUDA) [6] which is an architecture for general purpose computing using GPUs General Purpose Graphics Processing Units (GPGPU). It includes a new parallel programming model and the purpose is to solve certain computational problems more efficiently than on a CPU. Recent device models have a theoretical maximum of several Tera floating point operations per seconds. CUDA enables these processing capabilities to be used generally and not just for graphics, and it is today often used in scientific settings from computational structural mechanics to bioinformatics and life sciences [7].

The recent GPUs are effectives and are an important tool to implement and to accelerate stereo algorithms, by exploiting their potential parallelism and memory bandwidth [8]. In this paper we present the details of a fast GPU 3D reconstruction implementation using CUDA. The proposed algorithm uses two stereoscopic video sequences as inputs and then it processes the two stereoscopic images to obtain a disparity map. To obtain stereo correspondence we have used the stereoscopic Block Matching (BM) algorithm running on GPU and then we can visualize a 3D reconstruction in real-time. The 3D visualization of the scene is formed by a set of 3D point clouds. In addition, we compare the performance of our implementation on selected GPUs with a CPU one.

The rest of the paper is organized as follows. Section II presents some basics definition and briefly reviews on 3D reconstruction and visualization using GPU. The implementation of our proposed system is presented in Section III. Section IV shows the experimental results of our system. Finally, Section V is devoted to concluding remarks and some suggestions for future work.

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